Deerfield Beach Transit Option Study - Technical Memorandum #2: Recommendation for Demonstration of Park and Ride Service

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DEERFIELD BEACH TRANSIT OPTION STUDY

Technical Memorandum #2

Recommendation for Demonstration of Park and Ride Service

April 1995
DEERFIELD BEACH TRANSIT OPTIONS STUDY

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Recommendation for Demonstration of Park and Ride Service

Prepared for:

City of Deerfield Beach

By:

Center for Urban Transportation Research
College of Engineering
University of South Florida

April 1995
ACKNOWLEDGEMENT

The Center for Urban Transportation Research (CUTR) has been approached by the City of Deerfield Beach to help develop transportation methods for alleviating traffic congestion and parking problems at the beach.

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INTRODUCTION

The permanent residential population of the City of Deerfield Beach in 1993 was 47,639.\(^1\) During the peak season, the population of the City increases on average by approximately 20 percent. As a result of the increased population of tourist and visitors to the City, local roads which provide access to and mobility at the City's beach develop capacity problems. Traffic congestion results on Hillsboro Blvd., the principal access to the beach, and on SR A1A which provides north-south movement on the barrier island. Additionally, this problem is exacerbated on Hillsboro Blvd. and SR A1A when the bridge across the Intracoastal Waterway is open.

This Technical Memorandum presents a recommendation for the demonstration of a park and ride transit service between the beach and mainland locations in the City of Deerfield Beach. It begins with an overview of information from the beach survey and other information from *Technical Memorandum #1: Background Information*, which provides the basis for the demonstration project. The survey was conducted on Thursday and Saturday. The analysis of the survey shows that 36 percent of respondents on both days are willing to use park and ride service to the beach from the mainland.

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I. EVALUATION OF TRANSIT DEMONSTRATION PROJECT

This section presents the proposed transit demonstration route between a park and ride facility on the mainland and the beach that mitigates congestion and helps meet travel demands to the beach.

The beach surveys in the first Technical Memorandum of the study are reviewed and provide a basis for examining the feasibility of a park and ride service. Information from the survey suggest that traffic and parking are a problem on Saturday but not on Thursday. The survey also showed that the vast majority of permanent and seasonal residents are not willing to use a transit service to the beach from locations in the further western locations of the City of Deerfield Beach. Comments from respondents on both days of the survey, as well as observations by surveyors, indicate that most traffic congestion problems are not along the beach itself. The major traffic problems are along Hillsboro Blvd. and SR A1A, especially when the drawbridge is open.

Review of the surveys also shows that 36 percent of Thursday’s and Saturday’s respondents are willing to use a transit service from a parking facility near US 1. The clear majority of these respondents are also willing to pay a fare of $.75 for a one-way trip.

Fewer respondents (17%) were willing to use transit from far western locations in the City of Deerfield Beach, if it were provided every 30 minutes. Only six percent are willing to use such service if it operated every 60 minutes.

Most respondents perceive traffic congestion as a problem on the weekends. These respondents also perceive traffic congestion as a problem on the segment of Hillsboro Blvd. that crosses the Intracoastal Waterway, especially when the bridge is open, and where this roadway intersects with SR A1A at the beach. However, it is interesting to note that the most recent Traffic Circulation Element of the City Comprehensive Plan shows that the segment of Hillsboro Blvd. which crosses the Intracoastal Waterway and segment of SR A1A that intersect with Hillsboro Blvd., are functioning at an acceptable Level of Service (LOS). Additionally, the 1994 - 1999 Transportation Improvement Plan (TIP) for Broward County does not show any planned improvements for the this roadway segment.
Transit Option

The above information provides a basis for establishing a limited park and ride transit service from the mainland to the beach in the City of Deerfield Beach. This type of transit service is the most promising solution to the problems of traffic congestion and parking at the beach in the short-term. However, the recommendation in this report is that the City consider this as a demonstration project that would help determine the feasibility of a potentially larger permanent project. Initially, the service should be provided during the winter season. It could also be provided on weekends during the off-season as an experiment. The City could operate the service free or at a very low cost to passengers to minimize the barriers against its use.

The potential benefits of this type of transit service include: reduced traffic congestion along Hillsboro Blvd. and the bridge crossing the Intracoastal Waterway; reduced demand on the limited number of public parking spaces at the beach; and attracting and delivering more people to the beach without creating more traffic congestion or requiring additional parking.

A park and ride demonstration would require the provision of parking opportunities in the vicinity of the Cove and/or Palm Aire Shopping Centers along Hillsboro Blvd. The park and ride lots could be provided in existing lots by agreement with the owners or they could be constructed by the City of Deerfield Beach. People traveling to the beach would park their vehicles in the lot and transfer to a transit vehicle. Appendix A provides a guide for the Design of High Occupancy Vehicle and Public Transfer Facilities.

Figure 1 depicts the proposed route for the service. Transit vehicles would travel to the beach along Hillsboro Blvd., cross the bridge over the Intracoastal Waterway, turn left onto SR A1A, and travel along SR A1A to Ocean Way (near the pier), make a right turn onto Ocean Way and travel south to Hillsboro Blvd., turn right onto Hillsboro Blvd., and continue west to the park and ride location. The proposed service is not designed to travel far south on Ocean Way, in order to avoid possible traffic congestion along SR A1A. The congestion that occurs on SR A1A would prevent the service from providing adequate frequency.

A similar route is used for fixed route service that is operated by BCT in the City of Deerfield Beach. Route 50 provides service between south Deerfield Beach and the beach using Dixie Highway and Hillsboro Blvd. Headways on this route vary from 30 minutes on weekdays, to 45 minutes on Saturday and 60 minutes on Sunday. Route 92 provides limited service to the beach along Hillsboro Blvd. from western locations in the City of Deerfield Beach.
Figure 1
Proposed Park and Ride Service for City of Deerfield Beach

Legend
- Proposed route
Potential Ridership

Park and ride lots at the Cove and/or Palm Aire Shopping Centers are recommended because most traffic destined to Deerfield's beach passes through the intersections near these locations. The Cove Shopping Center is near the intersection of Hillsboro Blvd. and 15th Avenue and the Palm Aire Shopping Center is near the intersection of Hillsboro Blvd. and Federal Highway (see Figure 2). Use of a part of the existing parking lots at these shopping centers would be ideal.

The Broward County 1993 Annual Average Daily Traffic (AADT) volumes are used to predict potential ridership for the service. This information showed that the segment of Hillsboro Blvd. east of 12th Avenue had a bidirectional AADT of 20,900 in 1993 (See Figure 2). When calculated for one-way traffic this equals an AADT of 10,450.

Figure 2
Annual Average Daily Traffic Volumes at Hillboro Blvd. and E. 12th Ave.
One approach to projecting ridership for new transit services is to use Census Journey-to-Work data. This method is incomplete for this study since it focuses on work trips rather than recreation trips, but it provides one indicator of potential ridership. For this study, 1990 Census Journey-to-Work data is also used to estimate average vehicle occupancy (AVO) for vehicles in Broward County. By relating this data with AADT on Hillsboro Blvd, it is possible to estimate the number of transit trips that might be affected by the service. Table 1 provides the distribution of mode choice for workers in Broward County.

**Table 1**

Distribution of Mode Choice for Workers in Broward County

<table>
<thead>
<tr>
<th>Mode</th>
<th>Broward County</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive Alone</td>
<td>80%</td>
</tr>
<tr>
<td>Car/Vanpool</td>
<td>11%</td>
</tr>
<tr>
<td>Transit</td>
<td>1%</td>
</tr>
<tr>
<td>Work at Home, walk, bicycle, or other</td>
<td>8%</td>
</tr>
<tr>
<td>AVO*</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Source: 1990 Census Journey-to-Work Data  
AVO = %drivers + %passengers  
%drivers

The product of the AADT at Hillsboro Blvd. and 12th Avenue and the estimated AVO for traffic in Broward County represents the potential market, or transit trips. The results are shown in Table 2.

**Table 2**

Deerfield Beach Potential Transit Market Size  
(Hillsboro Blvd. and 12th Avenue)

<table>
<thead>
<tr>
<th>Location</th>
<th>AADT - Bidirectional Volume</th>
<th>Average One-Way Volume</th>
<th>AVO</th>
<th>Person Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillsboro Blvd. and 12th Avenue</td>
<td>20,900</td>
<td>10,450</td>
<td>1.2</td>
<td>12,540</td>
</tr>
</tbody>
</table>

Using these data, it is possible to develop one scenario of ridership levels. Nationally, transit carries approximately 2 percent of person trips and approximately 5 percent of work trips (7.62% in urbanized areas). Florida numbers are lower due to lower densities, less concentrated employment and lower levels of transit service. For conceptual planning purposes it is
recommended that the lower 2 percent mode share be utilized. Assuming a potential market size of 12,540 person trips, this translates to approximately 500 transit trips.2

Ridership for transit service to the beach from the mainland can also be estimated by relating the number of city operated parking spaces at the beach with the percent of respondents in the survey that said they were willing to use the service. Additionally, data from the beach survey are used to estimate average vehicle occupancy (AVO) for vehicles traveling to the beach.

The City reports that there are 500 parking spaces on the barrier island. Data from the survey show that between 36 percent of respondents on both days are more willing to use park and ride service to the beach from the mainland. The survey also revealed that the average size of parties at the beach was two. Thus, it can be assumed that vehicles traveling to the beach have an AVO of two. Table 3 presents ridership using these data. The analysis show a ridership estimate of 360 one-way person trips or 720 transit trips.

<table>
<thead>
<tr>
<th>City Parking</th>
<th>Percent of respondents willing to use transit</th>
<th>Market Size</th>
<th>AVO*</th>
<th>Person Trips</th>
<th>Transit Trips**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>36%</td>
<td>180</td>
<td>2</td>
<td>360</td>
<td>720</td>
</tr>
</tbody>
</table>

*Assumes a party size of two persons per vehicle.  
**Assumes that persons using transit to the beach will return by transit.

Initially, the demonstration project is proposed only for service during the peak season, and perhaps on the weekends during the off-peak season. The service should operate with 10 to 15 minute headways between the hours of 10:00am and 5:00pm. The service will need two vehicles to maintain headways.

Cost Considerations

In the first Technical Memorandum of this study, several beach cities in Florida were surveyed about traffic congestion and parking problems. A few of these cities indicated that as a result of traffic congestion, a trolley or transit service was developed to mitigate this problem. Subsequent interviews with the trolley or transit operators provided information on cost to operate the service. This is useful in developing operating cost for the transit service that is being recommended in the City of Deerfield Beach.

\[
\text{For this analysis, it is assumed that persons using transit to the beach will also return by transit. Thus, this estimate is the product of: } 12,540 \times 2\% \text{ (mode share target)} = \frac{250 \times 2 \text{ (round trip)}}{500} \]
Table 4 presents hourly operating cost for trolley or transit service in Florida Cities. This includes annual cost and hourly costs.

<table>
<thead>
<tr>
<th>City</th>
<th>Annual Cost</th>
<th>Hourly Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasure Island</td>
<td>$50,200.00</td>
<td>$17.24</td>
</tr>
<tr>
<td>Ft. Lauderdale</td>
<td>$106,434.00</td>
<td>$36.45</td>
</tr>
<tr>
<td>Hollywood ¹</td>
<td>$46,800.00²</td>
<td>$39.00</td>
</tr>
<tr>
<td></td>
<td>$70,520.00³</td>
<td>$41.00</td>
</tr>
<tr>
<td>Average</td>
<td>$91,318.00</td>
<td>$33.42</td>
</tr>
</tbody>
</table>

¹Annual cost approximately $117,320.00.
²Reflects service cost from October through April.
³Reflects service cost from May through September.

For conceptual purposes, operating cost for park and ride service to the beach from locations in the City of Deerfield Beach are estimated using an average of the hourly cost shown in Table 3. When calculated this equals an average hourly rate of approximately $33.42. Table 5 presents a cost per revenue hour estimate for the proposed park and ride service, assuming approximately 7 hours of service per day.

<table>
<thead>
<tr>
<th>Cost per revenue hour</th>
<th>Revenue Hours</th>
<th># of Vehicles Required</th>
<th>Operating Cost*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$33.42</td>
<td>7</td>
<td>2</td>
<td>$468</td>
</tr>
</tbody>
</table>

Operating cost = Daily operating cost ($234) * vehicles required to maintain headway (2) = $468

The above cost estimate for transit service to the beach from a park and ride location in the City of Deerfield Beach does not include capital cost, i.e., vehicle purchase, marketing, or shelters.

Table 6 shows operating cost for service 365 days, 52 weekends, and seasonal weekends. Weekends include Friday, Saturday, and Sunday. Peak season for the City of Deerfield Beach is from December to April, approximately 21 weeks.
Table 6
Service Options Cost

<table>
<thead>
<tr>
<th>Service Option</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>365 days</td>
<td>$85,410 * 2 (vehicles) = $170,820</td>
</tr>
<tr>
<td>52 weekends</td>
<td>$36,504 * 2 (vehicles) = $73,008</td>
</tr>
<tr>
<td>21 weekends*</td>
<td>$18,252 * 2 (vehicles) = $29,484</td>
</tr>
</tbody>
</table>

*Includes weekends from December to April.

Marketing Considerations

To be successful, the proposed demonstration project will need to be vigorously marketed to insure public awareness and support. Increased awareness of the service will encourage the scheduling of trips to the beach so that residents and non-residents can take advantage of the service. Similarly, providing information to employees at the beach on the benefits of using the service rather that driving will help to reduce traffic congestion on Hillsboro Blvd. and the bridge.

Other opportunities for marketing park and ride service to the beach include: special promotions, such as periodic prize drawings and contests, discounts from retail locations to patrons that use transit to make their trip; transit subsidies from employers to employees who use transit for work trips; and marketing transit service to tourist and visitors via hotels (handouts placed in hotel rooms) in the area. Effective signage along Hillsboro Blvd., SR A1A, and in the Cove and Palm Aire Shopping Centers, to further increase public awareness of the service, will help attract ridership. Handouts about the service can be given to motorists stalled in traffic approaching the bridge across the Intracoastal Waterway and maps can be placed under the windshield blades of cars parked at the beach and shopping centers. Additionally, TV, radio, newspaper, and other media could be selectively used conveying the message "take transit to the beach." If the City distributes any mailings to residents on a regular basis, news about the transit service should be included.

Finally, the City needs to involve the community and local businesses in the planning and implementation of the service. Some may be willing to contribute to the cost of the service if they believe it will make the beach more attractive and draw more people to the beach or shopping center.
II. FINANCING OPTIONS

Since the park and ride service is being proposed first as a demonstration project, there are possible financing sources from the federal and state level:

- The Florida Department of Transportation (FDOT) Service Development Program was enacted by the Florida Legislature to provide initial funding for special projects such as a park and ride demonstration. The program is selectively applied to determine whether a new or innovative technique or measure can be used to improve or expand public transit. These include the use of new technologies, services, routes, or vehicle frequencies, the purchase of special transportation services, and other such techniques for increasing service to the riding public as are applicable to specific localities and transit user groups. Funds may be used for capital and operating costs. Funds under this program are subject to specified times of duration, but no more than three years. The trolley service that operates in the City of Fort Myers Beach began as a demonstration project using funds from this program. The City of Deerfield will need to confer with the District IV staff of FDOT and submit its proposal for a service development program grant to FDOT and the Broward County MPO.

- State funds for capital costs related to renovating parking lots for the proposed service are available from the Federal Aid to Urban Systems (FAUS) program. These funds are derived from the Federal Highway Administration but administered by the FDOT. These funds should also be considered for financing permanent park and ride lots, if the demonstration is successful.

- The City may consider funds from the Congestion Mitigation and Air Quality Improvement Program (CMAQ), which is part of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991. This program allows a state to obligate funds apportioned under this program, for congestion mitigation and transportation air quality improvement projects and programs in ozone and carbon monoxide (CO) nonattainment areas. Projects are eligible for CMAQ program funds only if they meet certain criteria in the ISTEA. An important aspect of the criteria is that the project must provide measurements of how the service will reduce air pollution. The application process for CMAQ funds will be the same as the process for service development program grant.

- The City may consider designating the geographic area along Hillsboro Blvd. and SR A1A that will be served by the proposed park and ride service as a special assessment...
district. Funds derived from this assessment may provide adequate funds for capital and operating expenses. Typically, an assessment district is used to assess an equitable portion of a service's cost from property owners who benefit from the improvements. Property owners are then assessed their fair share of the annual debt service. A special assessment district was established in Tampa to support a shuttle service in the Westshore business area. In 1983, the Dade County Board of Commissioners approved an enabling ordinance that established a special benefit assessment district to support the initial phase of the downtown Miami Metromover system.

- Funds to support the proposed service are also possible from the farebox, if a fare is charged for passenger trips. Additionally, contributions from the City of Deerfield Beach business community should be sought to encourage a public-private participation on the this project, thus, making the success of this project dependent on both the City and the business community.
III. ADDITIONAL CONSIDERATIONS

Aspects that need to be considered before implementing the proposed park and ride service are presented below.

• Before implementation of the service, planning efforts by the City of Deerfield Beach are needed for coordination with other local transit service, i.e., Broward County Transit, Palm Beach County Transit, and Tri-County Commuter Rail. This will facilitate easy transfers for passengers from other local transit systems to the proposed park and ride service.

• Surveys at the beach revealed that many respondents were not willing to use transit because of condiments and beach accessories that they bring to the beach. Thus, the City will need to consider a policy for carry-on items, i.e., bikes, rollerskates/blades, surfboards, coolers, and wet swimsuits.

• The American with Disabilities Act (ADA) requires that transit vehicles be designed to accommodate people with disabilities. The City will need to make sure that the vehicles that are used for the service will meet ADA requirements, i.e., wheelchair lifts and facilities for sight and hearing impaired.

• Depending on the type of financing strategy that is used to support the proposed service, the City should consider a fare structure. A simple structure might include regular fare for adults and discounted fares for children, seniors, and disabled persons. Surveys revealed that some respondents are willing to use the service and pay a fare of $.75. Additionally, transfer policies with other local transit operators will need to be established.

• The City may need to negotiate an informal agreement with the Cove and Palm Aire Shopping Centers for parking spaces prior to the start of the proposed demonstration project (See Appendix A). Additionally, the City needs to consider allocation of human resources and project management for the proposed service. For example the City will need a project manager, advisory committee, drivers, vehicle procurement, production and placement of signage, bus stop amenities, and production and distribution of printed materials.
IV. PROJECT GOALS AND EVALUATION

The proposed park and ride demonstration project will improve the transit service to the beach for permanent and non-permanent residents in the City of Deerfield Beach. The goals of the demonstration project should include:

1) attract sufficient ridership to justify the establishment of a permanent park and ride service that relieves parking and traffic problems;

2) reduce traffic congestion along Hillsboro Blvd., especially traffic destined to the beach;

3) improve safety by diverting pedestrians from the shoulders of SR A1A; and

4) stimulate business in the City of Deerfield Beach.

The evaluation criteria and measures which will help evaluate the project’s success in achieving these goals are presented below.

- **Ridership** - Attract ridership in excess of three passengers per vehicle revenue mile. This measure is higher than the 1994 passenger per vehicle revenue mile average for fixed routes (Rtes. 50 & 92/94) operated by BCT in the City of Deerfield.

- **Impact on traffic** - Vehicle counts made during the demonstration period can be compared with prior year counts to help evaluate the demonstration impact on person and vehicle flows on Hillsboro Blvd. and SR A1A.

- **Pedestrian accident reports** - Pedestrian accident reports on SR A1A during demonstration period can be compared with prior years, provided reports are available.

- **The economic impacts** - The economic impacts on businesses can be estimated by interviewing business people and conducting on-board survey of passengers.
V. ADDITIONAL STRATEGIES

Information from the survey and discussions with various officials in Broward County and the City of Deerfield Beach reveal other possible alternatives to mitigate traffic and parking problems at the beach. Additionally, traditional methods for reducing traffic congestion were researched. These techniques and their application to traffic parking management in the City of Deerfield Beach are presented below.

- Determine if the Hillsboro Blvd. bridge which crosses the Intracoastal Waterway would allow more surface traffic to pass over the bridge if it were timed to open on the hour and half hour. If data from the analysis reveal that retiming bridge openings will improve traffic flow across the bridge, the City should petition the Coast Guard to implement the new times as part of its traffic management strategy.

- The City should make the beach more accessible to bicyclists by improving bikeways and providing secure facilities to park bicycles. This form of transportation requires far less highway and parking space, and is particularly appropriate for a recreation destination. It could help reduce auto trips that are made by parents dropping their children off, and could also attract teenagers with access to cars to use their bicycles instead.

- In addition to the proposed park and ride service, the City should explore cooperative agreements with BCT and any private providers of bus service to the beach to allow people parking at the park and ride site free passage to and from the beach. BCT could record the number of passengers boarding and charge the City accordingly. This would provide park and riders with as many as seven transit vehicles an hour going in both directions, which is a more convenient level of service.

- Better signage is needed at the beach to alert people to the fact that there is more parking toward the south end of the beach. This would discourage cars that wait for spaces to open at the northern end. Additionally, the City should consider placing an electronic flip dot sign on Hillsboro Blvd. alerting people when beach parking is full. This would provide further encouragement to use the park and ride service.

- The City should consider raising the price of parking on the beach to $1.25 per hour to encourage more people to use the park and ride service and to help pay for the service.
- Signage should be placed near the bridge over the Intracoastal Waterway to advise people that the bridge opens on the hour, at 20 after and 40 after the hour. This will encourage people to plan their trips in such a way as to avoid bridge openings.

- The City of Deerfield Beach can receive assistance from Gold Coast Commuter Services in establishing a local task force and in promoting the park and ride service in the community. This is part of Gold Coast's responsibility under its contract with the FDOT.
APPENDIX A

Guide for the Design of High Occupancy Vehicle
and Public Transfer Facilities

Digitization Note: Appendix A was originally photocopies
of another work with 2 pages per copied page, and of
poor quality. To increase readability, the pages have been
separated.
Guide for the Design of High Occupancy Vehicle and Public Transfer Facilities

1983

Published by the American Association of State Highway and Transportation Officials
444 North Capitol Street, N.W., Suite 225
Washington, D.C. 20001
PART II
DESIGN OF TRANSFER FACILITIES

A. GENERAL

This section of the design guide contains an overview of the important features needed to design a functional transfer facility. After the need for a facility has been established and the site selected, the next step is to determine the physical design and layout of the facility. This should be done under the direction of the appropriate design and traffic engineers in cooperation with other local agencies including the transit operating authority. Design features should be in compliance with applicable design standards, specifications and operating policies, or local requirements and zoning regulations that may apply.

Consideration is given to a number of design components including geometric design of access points and internal circulation, parking space layout, pavements, shelters, bicycle facilities, traffic control devices, lighting and landscaping. When dealing with a specific site, it will often not be possible to optimize each feature and compromises will be required. The degree to which the desirable attributes of any component is sacrificed to obtain the benefits of a competing component can only be dealt with on a site specific basis. However, these guidelines will present, to the extent possible, the optimum requirements of each factor. Primary concerns during the design stages should include: safe and efficient traffic flow for all modes; transit, carpools, vanpools, pedestrians and bikes, both on and adjacent to the site; an adequate number of usable parking spaces; facilities for the user which are comfortable and attractive; and facilities that accommodate use by elderly and handicapped patrons.

The primary emphasis is on park-and-ride facilities which utilize private automobiles as the collector/distributor mode and transit buses as the line-haul mode. However, many of the basic principles herein will be useful in designing park-and-pool lots which are typically smaller and less sophisticated than park-and-ride lots. However, some vanpool or carpool activity will occur at most park-and-ride lots and should be considered in the facility design, as it presents the possibility that internal circulation will be somewhat more complicated. Another activity to be considered is the kiss and ride activity. This may also add to the internal circulation problem if not properly incorporated into the facility design.

Additional sources of information are available in the Bibliography, Appendix "D".

B. COORDINATION OF TRAFFIC NEAR TRANSFER FACILITIES

I. General

This section is intended to give the user some direction in assessing the impact of a proposed transfer facility on the surrounding street and highway.
network. Users are referred to the Highway Capacity Manual (Highway Research Board Special Report 87) and to AASHTO's Policy On Design Of Urban Highways and Arterial Streets, current editions, as reference guides for the solution of capacity problems.

2. Bus Stops On Major Arterials

The effect of bus stops on urban street capacity is shown in the Highway Capacity Manual. The choice of the location of the bus stop (near side or far side of Intersection) should take into account how well the stop serves patrons and how the stopped bus will affect traffic operations. In addition to being safer for pedestrians, far side stops have an advantage over near side stops in that: (1) other buses or vehicles may turn right or left without interference from a bus stopped to load or unload passengers; (2) heavy right turn movements off the arterial are not hindered; (3) the curb lane may be used to store vehicles during the red phase of signal cycles; (4) sight distance conditions are helped especially at unsignalized intersections.

Many transit operators favor the near side stop as buses may load and unload during the red portion of signal cycles and buses retain the option to turn at the intersection rather than travel to the next intersection beyond the far side stop to turn.

At least one block should be provided for a bus to make lane changes prior to it turning left after it has loaded or unloaded passengers. Mid-block bus stops should be avoided when the bus must turn left at the next intersection.

Mid-block stops have the same advantages over near side stops as far side stops except where parking is allowed. Mid-block stops may also require cross walks and special pedestrian signalization.

3. Priority Signalization

Traffic control devices installed on arterial streets generally favor continuous automobile traffic and work to the disadvantage of transit vehicles that must stop for passengers regardless of signal indication. This added delay to transit vehicles tends to discourage patronage and further aggravates automobile traffic problems. The use of priority signalization for transit vehicles at intersections can decrease travel time. If transit is allowed to hold the signal indication too long, the delay to other traffic could result in trapping transit vehicles in stagnant traffic flows. Thus, a balance must be struck between decreased transit delay and increased automobile travel times when priority systems are used. Additional information can be found in the National Cooperative Highway Research Program (NCHRP) Report Number 143 (pp 71-75) and Number 155 (pp 121-124).  

*Available from the Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC 20418*
Pullouts have the advantage of separating buses from other traffic while they load and unload passengers; however, the additional right-of-way requirements for turnouts limit their use in many urban situations. To be fully effective, the turnout should incorporate a deceleration lane or taper, adequate standing area for all anticipated buses and a merging lane or taper. Further discussion is contained in the AASHTO design manual, "A Policy On Design of Urban Highways and Arterial Streets", current edition, for specific design values and Figure II, 1-a and 1-b of this guide.

5. Entrance and Exit Capacity of Park-and-Ride Lots

Movements into and from park-and-ride lots have been addressed in the Highway Capacity Manual. An example problem deals with the calculation of entrance capacity volumes for a parking facility and the effect that this facility will have on the volume and capacity of the arterial and intersections near the lot entrance. Exit capacity determination could be found by applying the methods of the Highway Capacity Manual dealing with turning movements. It is assumed that vehicles are able to arrive at the exit in sufficient numbers to use the calculated capacity.
One of the design problems often encountered concerns the limitations of existing streets or interchanges in the vicinity of the transfer facility. Ideally, the bus route from the freeway to the lot, circulation patterns within the lot and route back to the freeway will be located to minimize delay. At some outlying lots where operating costs assume critical importance, exclusive slip ramp connections both to and from the freeway or street may be justified based on reduced transit costs.

6. Traffic Control Devices

Traffic control devices should comply with the National Manual on Uniform Traffic Control Devices (MUTCD), current edition.

7. Traffic Signals

Traffic signals may be required at the exit of a large park-and-ride facility onto a major street to provide safe and efficient use of the facilities. Signalization should be considered only after a thorough study of traffic in the area and should be warranted or justified in the manner prescribed in the MUTCD. Existing traffic signals may require adjustments of timing or phasing to accommodate park-and-ride traffic.

8. Signing

"Lead-in" guide signing to the park-and-ride site could also be considered a part of the site selection process, particularly if the signing will be placed on a nearby freeway or other major facility. Locations for "lead-in" guide signing should relate to previous analyses used to define zones of influence which are expected to generate users of the park-and-ride facilities. The "lead-in" signs should be placed to intercept potential users on their normal paths and guide them directly to the facility. As an example, if a facility has been designed and located to attract drivers destined from a suburban residential area to a central business district, the primary "lead-in" signing should be located on the major arterials between the residential area and the park-and-ride facility.

Park-and-ride "lead-in" signs must be designed in accordance with the MUTCD as well as state and local criteria and policies for informational signs. The messages should be brief yet concise, with an indication of the service provided as shown in Figures 11-2 a and b. Signs should utilize standard guidance methods to direct traffic to the facility. Where traffic must be directed from a major highway, to a facility not visible from the highway, use should be made of trailblazer assemblies incorporating the park-and-ride legend or symbol and directional arrows as shown in Figure 11-2c.

Signs pertaining to moving traffic should be reflectorized, and some signs such as the entrance identification sign, may be lighted. Information signs should be placed in well-lighted areas. Signing in joint use park-and-ride areas, such as shopping centers, should not interfere with the owner's uses.
PARK-AND-RIDE SIGN EXAMPLES

FIGURE 11-2
C. PHYSICAL DESIGN

1. External Circulation and Access

a. Access Points

A major consideration in the location of a park-and-ride facility is the availability of access to and egress from the lot for both transit and the automobile. Access to the park-and-ride facility should not increase congestion on the arterial highway or freeway which it serves. For this and other reasons, direct access by private automobiles to a freeway or ramp will not typically be considered. However, direct access for buses is often desirable (see Figure 11-3). Further, direct access to an arterial route is not
desirable if it adds a major conflict point to the route. Often the most efficient access point to a park-and-ride lot will be on a collector or local street intersecting the arterial. If the intersection of the arterial with the collector street is already signalized, it is likely that excellent access can be provided.

When it is necessary to provide access on an arterial route, the access location must be carefully considered. It should be located to avoid queues from nearby intersections or freeway interchanges. Field observance of traffic patterns and queueing at the site are recommended prior to establishing an access point.

Locating a facility on the right side for traffic inbound on a two-way arterial will allow most users to make a right turn into the lot, thus eliminating the hazard of crossing an opposing traffic stream; and it is likely that maximizing the accessibility for the inbound trips will be more effective in attracting users than would improving the flow for exiting traffic in the evening.

Figure 11-4a illustrates a reasonable access configuration on a two-way arterial street. Note that it is desirable to provide separate one-way entrance and exit drives in order to minimize crossing conflicts. The distance from the exiting drive to any signalized intersection should be maximized to avoid the likelihood that it would be blocked by queues at the intersection. The critical operating period for this design can be expected to occur in the evenings when cars attempt to leave the lots and turn left onto the arterial. PM peak hour traffic flow should be evaluated and observed to determine if this is likely to be a serious problem. Demand activated traffic signalization of the arterial at the exit may be warranted. However, a new signal on an arterial should be considered only if it can be shown that it will not hinder arterial traffic and will fit into existing signal progression.

Entrances and exits should be located, with regard to adjacent intersections, so that signal control of the exit could be reasonably installed at a later time if necessary. Storage for vehicles entering from the street and adequate queue storage for exiting vehicles should be planned.

Figure 11-4b shows a modified design which may be feasible if the site has, or can obtain, access to a signalized cross street. In this case, exiting traffic is directed to the cross street and enters the arterial at an existing signalized access point. This design should not be considered if park-and-ride traffic would be directed over residential streets or alleys not suited to forecasted peak period volumes.

Both examples a and b of Figure 11-4 may require special treatment for transit vehicles coming from the central business district or activity center to enter the park-and-ride lot. Provision of left turn storage lanes should be considered.

When the park-and-ride lot is located on the left side of a two-way arterial for inbound traffic (as shown in Figure 11-4c), it is likely that left turn storage will be required to accommodate inbound cars in the morning.
PARK-AND-RIDE LOT ACCESS CONFIGURATION

FIGURE 11-4
Note that in Figure 11-4c, by placing the exit downstream from the entrance, the conflicts between vehicle flows to and from the arterial are minimized. When this is done, care must be taken to assure that adequate left turn storage is provided on the arterial for entering traffic and that the separation between the drivers is sufficient to assure that queued left turn vehicles will not block the exit drive, thus hindering buses and other vehicles attempting to turn left.

Park-and-ride lots located along one-way arterials require special considerations. Ideally, they would be located between the two streets comprising a one-way couplet and access would be available from both streets as shown in Figure 11-4d.

When access cannot be provided to both one-way streets from the park-and-ride lot, it may be necessary to provide improved signing to guide users either entering or exiting the facility. If express service will be provided, the close proximity of a freeway will allow good access for the transit buses as well as minimize their travel time on the slower moving arterials.

Planning, design and development criteria for access by feeder systems, such as paratransit, pedestrian ways, bikeways and kiss-and-ride, should be determined and provided for when the need is apparent. Where a strong need is determined, differing arrival modes should be allowed separate access points. This will provide increased safety, particularly when pedestrians and bicycles can be separated from motor vehicles, or cars from transit buses. It will also allow each arrival mode to be handled efficiently and directed to the proper area. It is recommended that a priority be established for treating the various transit modes, with constant attention given to pedestrians and bicycles, as they require very little room and are most vulnerable to inclement weather and conflict with other modes. The first priority would be given to transit vehicles in consideration of the fact that they accommodate more users than individual automobiles. Taxi and kiss-and-ride cars would have the second priority in an effort to minimize the time they would remain in the facility while park-and-ride cars would be given lowest priority. These priorities would be subject to adjustment in consideration of the numbers expected to be accommodated by each mode. However, it is necessary that access for each mode be designed on a logical basis and that the conflicts between modes be considered.

The design should also consider provisions for safe and convenient access by the elderly and handicapped.

Entrances and exits should be at least 150° feet apart and not closer than 150° feet to a public intersection, all measured curb to curb. Where the capacity of the parking area does not exceed 150 stalls, the above spacings may be reduced to 100 feet.

Whenever a park/ride lot has more than 300 parking stalls, at least two entrance drives and two exit drives should be provided. The volume per

*Minimum standard. 350 is desirable.*
lane should not exceed 300 vehicles per hour. It is desirable for park-and-ride lots with capacities greater than 1,000 parking stalls to have entrance and exit points to two or more adjacent streets in order to allow for uncongested traffic dispersal.

Entrances should be located such that a vehicle approaching the site from any direction could miss one entrance and find a second one available without circuitous routing. The number of vehicular entrances along any one street should be minimized and should be spaced at least 350 feet apart. Entrances should be located on the downstream side of an intersection.

Generally, right turns in and out of the lots are preferred to left turns. Therefore, the external circulation pattern around a facility should be clockwise. Where lot size is larger than 500 stalls, two lane exits with traffic signals should be considered for exits onto heavy volume two-way streets.

b. Weaving

Weaving standards and recommendations set forth in the Highway Capacity Manual or the AASHTO design guide on highway and intersection design should be followed and modified as conditions dictate and local ordinances allow.

c. Driveway Entrance and Exit

All driveways entrances and exits should conform to local criteria as well as AASHTO design guides.

2. Internal Circulation

Major circulation routes in the lot should be located at the periphery of the parking area to minimize vehicle-pedestrian conflicts. Circulation within the lot must be able to accommodate all of the various modes using the facility. Care should be taken to see that an internal intersection is not placed too close to a street intersection. Whenever possible, buses should not be mixed with cars.

Circulation routes should be designed to provide for easy movement of buses with efficient terminal operations and convenient passenger transfers. A one-way roadway with two lanes to permit passing of stopped buses is desirable, with enough curb length and/or saw-tooth type loading areas to handle the number of buses that will be using the facility, simultaneously, under peak conditions.

In designing park-and-ride lots, the passenger waiting area should be located either (a) in a central location with parking for the various user modes surrounding the waiting area, or (b) located near one end of the facility with parking for the various user modes extending radially from the waiting area. Large lots may also require more than one pick-up area. Fast and easy ingress and egress for the transit buses, paratransit vehicles and kiss-and-ride vehicles should also be paramount in the selection of the
internal layout. Figure II-5 is a sketch of a possible park-and-ride lot showing separate parking for each of the different modes.

Figure II-6 illustrates a similar concept; however, in this case, the parcel has no frontage on the major street. The lot is located behind other frontage uses.

In shared type lots, such as shopping centers, churches, etc., the waiting area should be located away from main building(s) so as not to interfere with existing business activity. Instead, it should tend to attract additional business.

Facilities for kiss-and-ride and taxis should accommodate two distinctly different functions. The first function is passenger arrival and drop-off and the other is passenger pick-up. This type of area should be designed for one-way traffic with a curb zone near the point where the transit vehicle is boarded. Angle parking with through stalls would be ideal for usage with this mode. Figure II-7 is a sketch of a possible kiss-and-ride and short-term parking layout.

Park-and-ride circulation can be either one-way or two-way depending on size and layout of the lot (preferably with right angle [90 degree] parking stalls to provide the highest parking density for a given area). The all day parking area should be located the farthest from the line haul transit loading and unloading area.
If it is anticipated that bicycle usage will be substantial, special two-way paths with signs and markings may be desirable. Bicycle lockers and racks should be provided to encourage usage. Bike parking should be located relatively close to the transit loading area, if possible.

Circulation in an undersized, irregular or odd shaped lot may have to be compromised in order to maximize its utilization. This compromise may require eliminating some of the park-and-ride areas in favor of some of the other modes of arrival at the lot.

The general design for the individual user modes of each lot should be based on the same priority sequence as specified in the "Access Points" section, namely, pedestrians, bicycles, feeder buses, taxis, kiss-and-ride, park-and-ride pay area (if any), and free park-and-ride area.
The system of traffic circulation produced by the arrangement of parking aisles and stalls should be designed to minimize vehicular traffic distances, conflicting movements, and number of turns. Vehicular movements within the parking area should be dispersed by strategic location of entrances, exits and aisles.

Aisles should preferably be aligned to facilitate convenient pedestrian movement toward the bus loading zone. Aisle length may be limited by offsetting aisles, or by changing the aisle alignment. Circulation should be counter-clockwise. Aisles should be one-way with angle parking and two-way with 90 degree parking.

The most important consideration of traffic flow into and out of any park-side lot is the bus. The internal layout of the lot, including entrance and exit driveways, revolve around the turning radius of the bus. Any layout which is prepared considering only automobiles will not likely easily accommodate bus movements.

Some additional considerations on internal circulation are:

(1) Drivers should not be confronted with multiple decisions at the same time.
(2) The distance from facility access points should be adequate to provide for maneuvering and to minimize conflicts.

(3) Adequate capacity should be provided at access and egress points.

(4) Signing should be simple.

(5) Flexibility to adjust to changes in transit volume and operations should be provided.

(6) Where larger transit passenger demands are present and park-and-ride/kiss-and-ride operations are involved, the terminal area should be located off-street but with convenient access to and from the arterial.

a. Reservoir Areas

A reservoir area should be considered adjacent to every entrance and exit, for the momentary storage of vehicles. The momentary storage of vehicles entering or leaving the parking lot should not interfere with the normal parking and unparking activities. This area's pavement structure should be the same as the rest of the lot.

The reservoir area may be provided in the form of a circulation road and/or an area extending in any direction. Where a circulation road is used, a 22' x 12' space should be provided per vehicle. Where an area other than a circulation road is used, a 22' x 10' space should be provided per vehicle.

b. Kiss and Ride Facilities

The kiss-and-ride facility should be so located within a park-and-ride lot so that transit or commuter passengers can easily and safely access the terminal or bus loading zone with minimum conflicts with other vehicles. This can be accomplished with the following strategies located so that their use does not interfere with bus movements, park-and-ride operations, or pass through the park-and-ride control zones. Circulation in the kiss-and-ride facility should be one-way and flank the terminal or bus loading zone. Parking should be angled at 45 degrees to allow for pull through and face the terminal or bus loading zone. (See Figure 11-8)

c. Signing

Within the facility, a number of types of signing may be required:

- Guide signing to direct vehicles to parking areas, passenger drop-off and pick-up points, handicapped parking areas, and waiting areas. In some cases, they will be required to direct bicycles or other special vehicles to appropriate areas.

- Regulatory and warning signs to control traffic flow on various roadways within larger sites, particularly at points with a potential for vehicular/pedestrian/bicycle conflicts.

- Parking restriction signs to designate areas where parking or stopping is prohibited.
- Information signs describing routes, costs, schedules and other pertinent data.

Guide signs may also be desirable, in large lots, to direct traffic out of the facility to major streets.

3. Pedestrian Movements

A direct and safe approach for pedestrians may be provided from all adjacent streets into the station area. Pedestrian facilities should be well marked and signed to minimize indiscriminate pedestrian movement.

Pedestrian circulation in parking lots is to be provided by aisles. Additional provision for pedestrian circulation by means of walkways may be desirable or could be required in certain situations, as described below.

The straight-line distance between a pedestrian's origin and a loading zone normally decreases as the pedestrian walks along an aisle or a circulation road toward the station. However, in certain situations, as shown in
Figure 11-9, the aisle layout may be such that the straight-line distance increases for a certain portion of the path traveled by the pedestrian. In any such situation, a pedestrian walkway should be provided wherever necessary to limit such a portion of the path traveled by the pedestrian to 50 feet. A pedestrian path from any parking stall to the loading zone should be as direct as possible. A coefficient of directness may be determined by:

Coefficient of Directness = \( \frac{\text{Length of Path}}{\text{Straight-line Distance}} \)

...is 1.2 to 1; however, it should not
Pedestrian walkways may be provided in certain locations to minimize pedestrian use of a circulation road or an aisle, or may be provided to minimize the number of points at which pedestrians cross a circulation road. Where pedestrians originate from an onlying part of a large parking lot and use aisles or circulation roads to approach the loading zone, they will have to travel along an irregular path for a considerable distance. In such cases, consideration should be given to the provision of a walkway which extends toward the loading zone in more nearly a straight line. In addition, some walkways may be covered.

Pedestrians must have right-of-way over vehicles at selected marked crossings or internal roadways.

Pedestrian crossings should have good visibility both for pedestrians and drivers. Curbs at all marked crossings between the handicapped parking facility and loading zone should be ramped.

Pedestrian crossings at any street wider than five lanes or 48 feet should have a refuge area between opposing lanes or in the center of the street.

Where walkways cross other walkways, driveways or parking lots, they should blend to a common level. Curbs should be sloped (with particular attention to major streets and access roads). The criteria for elderly and handicapped patrons should be considered.

Long ramps should be interrupted with level areas at least 5 feet long, at 30 foot intervals for rest stops or as specified by local code. These ramps should have handrails, 32 inches high, on at least one side.

Any type of raised pedestrian walkway should have a depressed curb ramp at changes of elevations (i.e. roadway surfaces) for handicapped wheelchairs use. The maximum grade should be 1' in 12' with a minimum width of 3 to 4 feet or as specified by local code.

Pedestrian facilities should provide a means of safe access to loading zones. A sidewalk should be provided contiguous to curb-side parking lanes and to all loading zones. Pedestrian facilities should be designed for the highest feasible level of service (See Table 2.1).

<table>
<thead>
<tr>
<th>Level of Service</th>
<th>Occupancy (Ft²/Person)</th>
<th>Flow Rate (PFM*)</th>
<th>In Queues Occupancy (Ft²/Person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>35 +</td>
<td>0-7</td>
<td>13 +</td>
</tr>
<tr>
<td>B</td>
<td>25-35</td>
<td>7-10</td>
<td>10-13</td>
</tr>
<tr>
<td>C</td>
<td>15-25</td>
<td>10-15</td>
<td>7-10</td>
</tr>
<tr>
<td>D</td>
<td>10-15</td>
<td>15-20</td>
<td>3-7</td>
</tr>
<tr>
<td>E</td>
<td>5-10</td>
<td>20-25</td>
<td>2-3</td>
</tr>
<tr>
<td>F</td>
<td>0-5</td>
<td>25 +</td>
<td>0-2</td>
</tr>
</tbody>
</table>

*PFM = Persons per foot width of sidewalk per minute
a. Walking Distance

The maximum distance a pedestrian should have to walk from his car to a loading zone should be in the range of 1000 feet. Longer walking distances may require consideration of additional loading zones.

b. Sidewalks

Sidewalks intended for use by the general public should have a minimum width of five feet for two-way pedestrian volumes (two-direction total count) not exceeding 50 pedestrians per minute. They should be compatible with local code or existing sidewalks in the area. When pedestrian volumes exceed this amount, an additional foot of sidewalk should be provided for every additional 10 pedestrians per minute. This corresponds to a level of service "C".

The minimum width of sidewalk adjacent to a bus or taxi loading zone should be 12 feet or the adjacent sidewalk width plus seven feet, whichever is greater. Sidewalks providing access to service and maintenance facilities may have a minimum width of three feet.

c. Barriers

Pedestrian barriers should be provided where it is desirable to either discourage or prevent pedestrians from crossing at locations where unusual hazard or unreasonable interference with vehicular traffic would otherwise result. Pedestrian barriers may consist of railing, fencing, walls or landscaping. These barriers should be used with sight distance in mind. Minimum horizontal clearance between a barrier and vehicle should be two feet.

d. Bridges and Tunnels

Pedestrian bridges may be used where feasible to separate high conflict areas, provided that differences in vertical separation do not, in themselves, become pedestrian barriers. The provision of pedestrian tunnels should be avoided if any other acceptable alternate design is feasible. Where tunnels are provided, they should have a generous cross section and should be well lighted. Tunnels should be placed so that continuous visibility is provided into the tunnel when viewed from the approaches. Maximum consideration should be given to the safety and protection of patrons and handicapped users.

4. Parking Dimensions and Layout

Basically, the parking site should offer safe, rapid parking and related movements for all users whether they be in a peripheral lot or a remote lot.

Parking areas for long-term parkers (park-and-ride) can be designed in much the same manner as other parking facilities. Standard dimensions for
parking stalls are recommended in Table 2.2. A reasonable number of short-term (kiss-and-ride) spaces, generally wider, will also be provided when required. Turnover in these spaces will be very high, but they are particularly needed for parking vehicles waiting to pick up passengers disembarking from line haul transit vehicles.

For many years, the trend in American automobile designs was toward longer and wider vehicles. However, due to the current energy conservation and cost considerations, this trend has been reversed and new cars are now being made shorter, narrower, lighter in weight, and more economical to operate. The larger American cars which were built prior to the 1977 models range in size up to 19.1 feet (5.5 m) in length and 6.66 feet (2.03 m) in width. The vast numbers of these larger cars now in use will gradually decrease. But, for the present, the greatest portion of the parking lot aisles and stalls must be dimensioned and marked to accept the largest automobiles that will use the lots.

It is apparent that the average size of cars in use is changing rapidly. The percentage of small cars (compact and subcompact) sold each year has risen. In consideration of this trend, parking lot layout should allow for future revisions to stall sizes, aisle widths and module dimensions. Additionally, it is reasonable, at this time, to designate specific areas within a lot for "small cars only" and to lay out these spaces at a smaller scale. These spaces should be placed together in a prime location to encourage their use, because if they are not convenient, small car drivers will park in the more conventional standard sized car spaces. (See Appendix "D" for a more detailed analysis of the effects of automobile size on lot design.)

Substandard stall and aisle widths are a false economy. Although they permit the marking of more stalls per given area, vehicles tend to encroach upon adjacent stalls so that one or more spaces are unavailable for use. The end result is no gain in actual space usage and a parking condition plagued by confusion.

There is normally a greater need for kiss-and-ride functions in remote lots, but space provisions should be made in both remote and peripheral lots. Adequate room should be available to permit the segregation of park-and-ride and kiss-and-ride functions. Separate lanes, near the point where the transit vehicle is boarded, should be provided solely for discharging and picking up kiss-and-ride patrons. In addition to facilitating kiss-and-ride patrons, this procedure avoids unnecessary congestion at the lot entrance due to kiss-and-ride queues.

Table 2.2
Typical Parking Dimensions

<table>
<thead>
<tr>
<th></th>
<th>Width</th>
<th>Length</th>
<th>Aisle Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>8.5'-9.5'</td>
<td>18'-20'</td>
<td>24'-26'</td>
</tr>
<tr>
<td>Compact</td>
<td>7.5'-8.5'</td>
<td>15'-17'</td>
<td>20'-22'</td>
</tr>
</tbody>
</table>
Sralls for the handicapped and elderly should be located in close proximity to the transit vehicle loading and unloading area. Stall widths should be at least 8 feet wide with a 5 foot adjacent loading aisle with sidewalk, ramps.

a. Stalls and Aisles

Aisle width is a function of the parking angle and stall width. One-way aisles are generally used with angle parking and two-way circulation is generally used with 90 degree parking.

Stall and aisle dimensions for all day parking should preferably conform to the 9' x 18.5', 90 degree standard or 8' x 16', 90 degree compact. All parking should be head-in only. Aisle lengths should not exceed 400 feet if possible. One-way aisles should favor counter-clockwise circulation.

In designing parking facilities, a common unit of measure is the parking module. A module consists of the width of the aisle, plus the depth of both parking stalls (measured perpendicular to the aisle). In many instances, parking modules are completely separated from each other. Another available module for angle parking is the interlocking module. The most common interlocking module is the one that places the bumpers of vehicles in adjacent stalls next to one another. This layout is illustrated in Figure II-10-11-12 along with parking dimensions for various angles of parking. At 45 degrees, a nested interlock is possible when adjacent aisles have one-way movement in the same direction. However, this places the bumper of one car adjacent to the front fender of another car and is not recommended, for the likelihood of damaged fenders is much greater than with other parking layouts.

The grades on the park-and-ride lot parking areas should be set so that drainage can be effective (1% minimum on either concrete or asphalt pavements). However, excessive grades of over 8%, parallel to the length of the auto, should be avoided. If this is not possible, rotate the parking layout up to 90 degrees to the excessive grade or use curbs or bumpers (wheel stops) except where snow removal may be required.

Double striping of stalls may be considered if sufficient space is available within the lot as a means of providing room for adding spaces when demand for the lot increases. Additional spaces could then be added by changing the marking rather than expending funds for additional construction.

Bus parking stalls should be a minimum of 13' by 42'. For articulated buses, the dimensions should be at least 13' x 60'.

Vehicles and other objects should be excluded from corners or parking spots where it is necessary to provide adequate intersection sight distances.

Design of the lighting layout and landscaping should be considered with the design layout criteria for a particular site. There will normally be some left-over areas in which a stall cannot be placed. These areas may be used for placement of light standards and/or landscaping, if compatible with the overall lot design.
### Parking Layout Dimensions (in feet) for 9-ft. Stalls at Various Angles

<table>
<thead>
<tr>
<th>Dimension (feet)</th>
<th>On Diagram</th>
<th>45°</th>
<th>60°</th>
<th>75°</th>
<th>90°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stall width, parallel to aisle</td>
<td>A</td>
<td>12.7</td>
<td>10.4</td>
<td>9.3</td>
<td>9.0</td>
</tr>
<tr>
<td>Stall length of line</td>
<td>B</td>
<td>25.0</td>
<td>22.0</td>
<td>20.0</td>
<td>18.5</td>
</tr>
<tr>
<td>Stall depth of wall</td>
<td>C</td>
<td>17.5</td>
<td>19.0</td>
<td>19.5</td>
<td>18.5</td>
</tr>
<tr>
<td>Aisle width between stall lines</td>
<td>D</td>
<td>12.0</td>
<td>16.0</td>
<td>23.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Stall depth, Interlock</td>
<td>E</td>
<td>13.3</td>
<td>17.5</td>
<td>18.5</td>
<td>18.5</td>
</tr>
<tr>
<td>Module, wall to interlock</td>
<td>F</td>
<td>44.8</td>
<td>52.5</td>
<td>61.3</td>
<td>63.0</td>
</tr>
<tr>
<td>Module, Interlocking</td>
<td>G</td>
<td>42.6</td>
<td>51.0</td>
<td>61.0</td>
<td>63.0</td>
</tr>
<tr>
<td>Module, Interlock to curb face</td>
<td>H</td>
<td>42.8</td>
<td>50.2</td>
<td>58.8</td>
<td>60.5</td>
</tr>
<tr>
<td>Dumper overhang (typical)</td>
<td>I</td>
<td>2.0</td>
<td>2.3</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Offset</td>
<td>J</td>
<td>6.3</td>
<td>2.7</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Setback</td>
<td>K</td>
<td>11.0</td>
<td>8.3</td>
<td>5.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cross aisle, one-way</td>
<td>L</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Cross aisle, two-way</td>
<td></td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
<td>24.0</td>
</tr>
</tbody>
</table>

**STALL LAYOUT ELEMENTS**

Standard: 9 x 16.5

**FIGURE 11-10**

If there is a desire to provide pedestrian refuge islands, walks, or internal landscaping, the interlocking parking module may be considered.

In the actual layout of parking stalls and circulation aisles, it is desirable to align the aisles parallel to the direction of pedestrian flow in the interest of safety. It is also desirable to have a row of parking on each side of the
X = Stall not accessible in certain layouts

Parking Layout Dimensions (In feet) for 8-1/2 Stalls at Various Angles

<table>
<thead>
<tr>
<th>Dimension (feet)</th>
<th>Diagram</th>
<th>45°</th>
<th>60°</th>
<th>75°</th>
<th>90°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stall width, parallel to aisle</td>
<td>A</td>
<td>11.3</td>
<td>9.3</td>
<td>8.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Stall length of line</td>
<td>B</td>
<td>23.6</td>
<td>19.0</td>
<td>17.3</td>
<td>16.0</td>
</tr>
<tr>
<td>Stall depth of wall</td>
<td>C</td>
<td>15.2</td>
<td>16.5</td>
<td>16.9</td>
<td>16.0</td>
</tr>
<tr>
<td>Aisle width between stall lines</td>
<td>D</td>
<td>12.0</td>
<td>13.5</td>
<td>19.5</td>
<td>22.0</td>
</tr>
<tr>
<td>Stall depth, interlock</td>
<td>E</td>
<td>13.3</td>
<td>15.2</td>
<td>16.3</td>
<td>16.0</td>
</tr>
<tr>
<td>Module, wall to interlock</td>
<td>F</td>
<td>40.5</td>
<td>45.2</td>
<td>52.7</td>
<td>54.0</td>
</tr>
<tr>
<td>Module, interlocking</td>
<td>G</td>
<td>38.6</td>
<td>43.9</td>
<td>52.1</td>
<td>54.0</td>
</tr>
<tr>
<td>Module, interlock to curb face</td>
<td>H</td>
<td>38.5</td>
<td>42.9</td>
<td>50.2</td>
<td>51.5</td>
</tr>
<tr>
<td>Bumper overhand (typical)</td>
<td>I</td>
<td>2.0</td>
<td>2.3</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Offset</td>
<td>J</td>
<td>5.4</td>
<td>2.4</td>
<td>0.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Setback</td>
<td>K</td>
<td>9.5</td>
<td>7.2</td>
<td>4.4</td>
<td>0.0</td>
</tr>
<tr>
<td>Cross aisle, one-way</td>
<td>L</td>
<td>12.0</td>
<td>12.0</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Cross aisle, two-way</td>
<td></td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
<td>22.0</td>
</tr>
</tbody>
</table>

STALL LAYOUT ELEMENTS

Compact, 9.5 x 15

FIGURE 11-12

aisle. This provides the most efficient design in terms of land area use. In addition, the greatest efficiency can generally be obtained by placing aisles and rows of parking parallel to the long dimension of the site. Greatest land use efficiency can usually be achieved by placing a row of parking com-
completely around the perimeter of the site. However, unless the park-and-ride site is very small, this practice is not recommended, because of the adverse effect on operational efficiency.
Efforts should also be directed toward establishing raised (6") paved walkways for pedestrians and patrons who are waiting to board the bus. When pedestrian walks are used in parking facilities, they should include ramps for the handicapped and direct pedestrians toward the transit loading area. Raised sidewalks may be used in larger facilities between rows of cars in order to aid pedestrian flow. Many pedestrians, however, will still use the stairs and the need for raised pedestrian walks is debatable. Raised sidewalks are not recommended for use in the snow belt.

5. Handicapped Parking

a. Capacity

The number of handicapped parking stalls should be as follows as a minimum:

<table>
<thead>
<tr>
<th>Total Parking Spots</th>
<th>Required Minimum Number of Accessible Spots</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 25</td>
<td>1</td>
</tr>
<tr>
<td>26 to 50</td>
<td>2</td>
</tr>
<tr>
<td>51 to 75</td>
<td>3</td>
</tr>
<tr>
<td>76 to 100</td>
<td>4</td>
</tr>
<tr>
<td>101 to 150</td>
<td>5</td>
</tr>
<tr>
<td>151 to 200</td>
<td>6</td>
</tr>
<tr>
<td>201 to 300</td>
<td>7</td>
</tr>
<tr>
<td>301 to 400</td>
<td>8</td>
</tr>
<tr>
<td>401 to 500</td>
<td>9</td>
</tr>
<tr>
<td>501 to 1000</td>
<td>10</td>
</tr>
<tr>
<td>over 1000</td>
<td>20 plus 1 for each 100 over 1000</td>
</tr>
</tbody>
</table>

b. Location

Handicapped facilities, similar to those shown in Figure II-13 should be provided at a location nearest the bus loading zone. The facilities should be in accord with the following:

- Preferably no access roads should be crossed by handicapped patrons enroute to the bus loading zone.
- The handicapped patron must never be forced to travel behind parked cars (in their circulation path).
- To facilitate the movement of physically handicapped patrons, wheelchair ramps must be provided (Figure II-13).

c. Design

Stall width should be 8 feet wide, plus 5 feet for access except end stalls.
d. Signing and Marking

Appropriate signing on pavement markings should indicate the restricted use of the space for handicapped persons. Curbs to and from the bus loading area should be depressed for wheel chairs as dictated by local standards.

6. Pavement

a. Drainage

Adequate slope should be provided to surface lots in order to minimize the possibility of low or flat spots. Ponding of water in a lot is undesirable both for vehicle and pedestrian movement. This is particularly true in cold climates where freezing may create icy spots. Surface drainage should be designed to avoid water collection in areas where pedestrians walk or stand. Recommended minimum grades are one percent (1.0%).

Curb, gutter and surface area drains and grates should be installed where needed to comply with the appropriate design standards and specifications. Their strength should be sufficient to withstand the maximum anticipated
vehicle wheel loadings (transit, maintenance or snow removal vehicles) and possess these other qualities: maintenance free, vandal-proof (bolt down grates), non-corrosive (gray or ductile iron) castings, sufficient open area (free flow area) to handle run-off, trapless to prevent freezing in winter, and be fitted with adapters that are compatible with the specified area drain piping. In pedestrian and bicycle traffic areas, only drainage grates with short, narrow openings, placed perpendicular to traffic flow direction, should be used to minimize the hazard and allow safe passage over the grate.

b. Pavement Types and Loadings

Pavement design should conform to the current local and state design specifications for each of the different usages and loadings that a particular portion of a lot or roadway is expected to handle. A park-and-ride lot may require as many as three different types of load carrying pavement designs. The first and heaviest load carrying pavement would be needed for the bus driveways, loops and loading area. That portion of the pavement which will be used by buses for loading or layover should generally be a rigid type, as flexible pavements may flow due to heavy static loadings and high temperatures. A second design for light load carrying usage would be needed for the internal circulation roadways and aisles and for the kiss-and-ride roadways. The third and lightest load carrying type pavement would be needed for the car parking areas and bicycle paths and parking area.

c. Pavement Widths

Pavement widths in the different sections of a park-and-ride lot should be designed consistent with good roadway engineering design practices to accommodate the vehicles designated to use that particular section. Driveways and loops that will be used by buses should have a basic width of 12 feet per lane for tangent sections. An increase to 15 feet per lane or more may be necessary for sharply curving roadways.

Specific geometric design information for layout of roadways for buses may be found in the AASHTO publication, "A Policy On Design of Urban Highways and Arterial Streets," current edition. A 40 foot transit vehicle may be used as the design vehicle where a local bus size is not specified. The basic width of roadways for cars should be 11 feet per lane. Lane widths would increase only two feet per lane or less for turns of up to 90 degrees. The minimum simple outer turning radius recommended is 25 to 30 feet for passenger cars.

Recommended minimum pavement widths for bicycle paths are five feet for a one-way path and eight feet for two-way paths. Local government agency standards and codes should be used whenever they exceed the design guide minimum. If desired, the widths may be increased to accommodate maintenance vehicles. The minimum recommended curve radius is 20 feet for a speed of 10 mph, which will provide a safety factor for the
cyclists who exceed the design speed. Where conditions may be conducive to higher speeds, radius of curvature should be increased accordingly or traffic control devices installed to warn the cyclist and/or regulate his speed.

7. Pavement Markings

Control of traffic movement can be greatly improved by proper pavement markings. Typically, reflectorized markings such as centerlines, lane lines, channelizing lines, and lane arrows will be necessary to guide or separate patron traffic and transit traffic.

Parking stall markings should be in accordance with the design concepts for parking stalls presented in a previous section. Stall markings need not be reflectorized, but must be maintained in good condition to assure orderly and efficient use of the parking area.

8. Bicycle and Motorcycle Storage

a. Designated Areas

With the growing use of bicycles and motorcycles, it is important to provide adequate storage facilities at those park-and-ride or fringe area parking lots where large concentrations of bicycle traffic are expected. In some central business districts, bike racks have also been placed in public and private automobile parking facilities.

In designing bicycle storage facilities, consideration should be given to the following: storage lot identification and accessibility, orientation of storage spaces, type of storage racks, lot boundary screening and protection, and provision of locking devices to minimize casual and professional theft.

Design principles for off-street automobile parking lots generally apply to off-street bicycle storage lots. The lot layout normally consists of stalls 2 ft. × 6 ft. (0.6 × 1.8 m) at 90 degrees to aisles of a minimum width of 5 feet (1.5 m). For motorcycles, the stall should be increased to 3' × 6'.

b. Racks, Lockers

Various types of parking racks have been developed to support the bicycles in a vertical position. The racks should be securely fastened to the lot surface; they should accommodate various wheel sizes; and they should be of sufficient strength to resist theft and vandalism. Some lots have single or double-wheel wells instead of vertical racks in the lot surface. These are more aesthetically pleasing, but cost, immobility, and difficulty of removing water, trash, and leaves constitute serious disadvantages.

Generally, the most successful method of theft prevention consists of weaving a case-hardened steel link chain ¼ to ½ inches (7.9 to 9.5 mm) minimum diameter or vinyl covered spring steel cable of similar dimensions through the frame and both wheels and then attaching it to the rack by means of a durable lock. Because a chain or cable of this size and adequate
length may weigh us much as 12 lbs. (5.4 kg), some authorities provide the anchored chains as part of the storage facility and the cyclist only has to provide his own lock. This design is usable by both bicycles and motorcycles. Motorcycle storage should be on a Portland cement concrete slab to prevent stands from sinking into the asphalt pavement.

Smaller, compact bike storage lots are preferred over large spacious lots because cyclists tend to cluster around the most desirable locations and tend to use aisles and fencing instead of moving past loaded racks to more distant empty racks.

If bicycle parking facilities are not protected by a curb, then the use of auto barriers should be considered. This will prevent damage by backing or passing vehicles. Bicycle lockers will discourage potential vandals by keeping the bicycle out of sight. Unlike bicycle racks, lockers will prevent removal of bicycle components. Moreover, bicycle commuters with expensive bikes would be more apt to use the parking facility if lockers were provided. The encouragement of the bicycle commuter is important. For each bicycle used to commute to the transfer facility, there is the possible freeing up of one additional parking space.

9. Shelters

a. Location

Shelters provide pedestrian users with comfort and protection from the weather. Shelters should be considered in areas where the magnitude of transit service and variation in environmental conditions warrant the expenditure of funds.

Shelters should be located adjacent to transit loading zones and kiss and ride zones.

Where on-street bus stops will be provided in areas with existing sidewalks, the shelters should be erected where the sidewalk is wide enough to accommodate them and cause only a minimum amount of interference with the pedestrian traffic. If the sidewalk is narrow where a shelter is to be erected at an on-street bus stop, the following should be considered: (1) obtain a property easement to allow the shelter to be placed behind the sidewalk, (2) redesign the shelter, or (3) widen the sidewalk.

b. Types

Shelters may be individually designed to satisfy local needs or selected from a variety of commercially available designs. Often an individual design for a large quantity may prove to be the most economical.

An analysis of essential design elements should be made in order to balance the physical need of the system with the aesthetics of the use. One survey concluded that the following typical physical features were preferred based on responses received from 230 transit agencies:

1. Length—ten feet (+), Width—five to seven feet, Height—seven feet (+).
2. Frame—metal.
3. Roof—metal or plastic.
4. Sides—Open, transparent glass or plastic.
5. Benches—50% preference.

The following additional features are recommended for consideration in selecting shelter designs:

1. Select open locations with good visibility, to minimize the chance of hidden nucleiators or vandals.
2. If enclosed, the open side should be away from nearby vehicle splashing, and two entranceways provided to minimize the chance of being trapped inside.
3. Doors are not recommended because of maintenance or vandalism potential, unless protection from weather dictates otherwise.
4. Allow for a small air space below side panels and above the ground to permit air circulation and prevent the collection of debris.
5. Other optional features that may be provided are lighting, heat, telephone, travel information (schedules), and trash receptacles.
6. If the agency purchases components to assemble and repair shelters with their own forces, consider ease of field assembly, and replacement when damaged.

The primary purpose of the shelter is to provide refuge from adverse weather while still presenting an attractive building that enhances use of the facility without creating unnecessary maintenance or safety problems.

c. Shelter Size

Shelter areas should provide eight square feet of covered structure per estimated occupant. The occupant load determination is as follows:

Number of Auto Drivers = 1.00 X
Number of Auto Passengers = 0.35 X
Number of People Who Walk To Facility = 0.15 X
Number of Kiss-And-Ride Patrons = 0.20 X
Number of Bicycle and Motorbike Patrons = 0.30 X
Total Number of Patrons = 2.00 X

X = Number of parking spaces

Assume 75 percent arrive in the morning peak hour—.75 (2.0X) = 1.5X. Assume the average waiting time is 10 minutes or 1/6 hours; therefore, the occupancy at any one time is ¼ (1.5X) = .25X. Using 8 square feet per occupant, the required shelter becomes 8 (.25X) = 2.0X or 2 square feet per stall. Therefore, a proposed park and ride structure size would be figured as follows: 500 parking stalls × 2 square feet per stall = 1,000 square feet. This, of course, is only a guideline and individual sites will need community input and research to determine their actual occupant load distribution factor.
Covered walkways should have a minimum clear height of 8'-0" and a minimum side overhang of 2'-0". The minimum width between support columns should be 6'-0".

d. Shelter Components

There is no substitute for the careful selection of materials in scale, texture and color which are appropriate considering the site. The following are general guidelines:

Residential Area
- Exposed wood structure.
- Wood deck, exposed on underside.
- Roof Cover: Cedar or composition shingles on pitched roof or built-up roof with gravel on flat roof.
- Wide overhang with built-in gutters and wood fascia.

Commercial Area
- Exposed steel frame structure.
- Metal deck, exposed on underside.
- Built-up roof with gravel or colored coating.
- Wide overhangs with built-in gutters and metal fascia.
- Brick screening and display walls of various heights.
- Exposed aggregate concrete floor.
- Covered walkways to kiss-and-ride and adjacent community.
- Roof compatible with structure design.

e. Shelter Flexibility

Modular construction techniques should be considered for shelter design and construction components.

Shelter design should consider expansion of the structure for future transit needs.

Interior facilities should be flexible for remodeling as future transit design demands.

f. Finish and Materials

During the selection of shelter finish materials, it is important that a cleaning program be considered and possibly developed as the materials are being selected. The cleaning and maintenance program is directly related to the selection of finish materials and has a considerable effect on the total cost. Maintenance problems are usually simplified through the use of as few different materials as possible.

g. Floors

Floors in heavy wear areas should have a wear surface separate from the structural slabs to facilitate replacement. Floors should have a dense, low absorption and soil resistant surface that provides good traction for pedes-
trains. Non-slip materials at platform edges and on stair nosings should be used to improve safety.

Floor drains should be installed adjacent to outside walls in below grade structures.

h. Walls

Walls should be of a polished, enameled or glazed surface to reduce cleaning and maintenance costs.

Exterior walls in below grade structures should have a cavity between the structural wall and finish wall to avoid moisture damage to the finish. Drainage holes should be provided at the bottom of the cavity. Walls should be started on a floor base to facilitate floor cleaning.

i. Ceilings

Ceilings must be designed to be resistant to damage or soiling and should be easily cleaned. Where suspended ceilings are used of the tile or pan type construction, the minimum floor to ceiling height should be 9'-0" to discourage damage by vandals.

j. Doors

Where doors are required, they should be faced with damage resistant materials to reduce maintenance costs.

k. Miscellaneous Metals

Handrails and metal trim should be of stainless steel, anodized aluminum, or other low maintenance material.

l. Windows

If used, windows should be of an unbreakable plastic. In lieu of windows, open sides or sides of transparent plastic should be used.

D. LIGHTING

Adequate lighting is important from a safety standpoint and serves as a deterrent to vandalism in both the parking area and the shelters. Mounting height and spacing of luminaires should be sufficient to provide the desired lighting intensity over the entire facility. All lighting should be vandal resistant.

A current desirable practice is to use higher mounting heights (50 ft.) or high-mast equipment (usually 60 ft. or higher) with the proper number of luminaires of sufficient light output to adequately illuminate the area. This type of lighting requires fewer poles and consequently presents fewer hazards to the parking motorist. The normal lighting level should range from one to two footcandles (fc) average maintained with a uniformity ratio (average illumination divided by minimum illumination) of not more than four to one. The lighting poles should be installed in protected areas or...
otherwise protected to prevent vehicles from hitting them. Poles should be so located that vehicle movements and parking are not obstructed. Their locations should be coordinated with the stall and aisle layouts. If raised islands are used to separate adjacent parking rows, the poles should be placed on the islands. In locating the lighting poles, future possible changes in the parking facility should be considered. Care should be taken in the lighting design to prevent undesirable light spillover into adjacent residential areas.

An energy cost savings may be possible and still provide security lighting by turning off 1/2 to 1/3 of parking area lights during low use periods. The control could be set so that a different group of lamps are left on every night during low use. This allows an even group lamp burn.

Lighting levels for parking and circulation areas shall be adequate for site safety and illumination, yet not infringe upon the adjacent community. The recommended illumination levels from the AASHTO "An Information Guide For Roadway Lighting" are shown in Table 2.5 and 2.6.

### Table 2.5
Average Maintained Horizontal Illumination* for Streets, Walkways and Bikeways

<table>
<thead>
<tr>
<th>Roadway and Walkway Classification</th>
<th>Commercial</th>
<th>Intermediate</th>
<th>Residential</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foot-Candle</td>
<td>Foot-Candle</td>
<td>Foot-Candle</td>
</tr>
<tr>
<td>Vehicular Roadways</td>
<td>Lux</td>
<td>Lux</td>
<td>Lux</td>
</tr>
<tr>
<td>Major and Expressway**</td>
<td>2.0</td>
<td>1.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Collector</td>
<td>1.2</td>
<td>0.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Local</td>
<td>0.9</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Alleys</td>
<td>0.6</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Pedestrian Walkways</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sidewalks</td>
<td>1.0</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Pedestrian Ways</td>
<td>2.0</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Bikeways+</td>
<td>2.0</td>
<td>1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*Average illumination on the traveled way or on the pavement area between curb lines or curbed roadways, when the illumination source is at its lowest output and when the luminaire is at its dimmest condition.

**Mainline and ramps. Includes expressway with partial control of access. Expressways with full control of access are covered in the section on freeways.

+ This assumes that the facility occupies a portion of a vehicular roadway. Separate facilities should use illumination levels for sidewalks.
### Table 2.6
Recommendecl Maintained Lighting Levels

<table>
<thead>
<tr>
<th></th>
<th>Footcandles</th>
<th>Lux</th>
<th>Uniformity Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance and Exit Gates</td>
<td>0.6</td>
<td>6</td>
<td>3:1 to 4:1</td>
</tr>
<tr>
<td>Interior Roadways</td>
<td>0.6</td>
<td>6</td>
<td>3:1 to 4:1</td>
</tr>
<tr>
<td>Parking Areas</td>
<td>1.0</td>
<td>11</td>
<td>3:1 to 4:1</td>
</tr>
<tr>
<td>Activity Areas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major</td>
<td>1.0</td>
<td>11</td>
<td>3:1 to 4:1</td>
</tr>
<tr>
<td>Minor</td>
<td>0.5</td>
<td>5</td>
<td>6:1</td>
</tr>
</tbody>
</table>


The above uniformity ratios are the maximum allowable. Lower numerical ratios produce better uniformity and are desirable.

For areas not covered in the above tables, the following levels are recommended:

<table>
<thead>
<tr>
<th>At-Grade Facilities</th>
<th>Minimum Maintained Illumination Levels (Foot Candles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading Platforms, Open</td>
<td>5</td>
</tr>
<tr>
<td>Loading Platforms, Under Canopy</td>
<td>15</td>
</tr>
<tr>
<td>Ticketing Areas—Turnstiles</td>
<td>20</td>
</tr>
<tr>
<td>Passages</td>
<td>20</td>
</tr>
<tr>
<td>Fare Collection Booth</td>
<td>100</td>
</tr>
<tr>
<td>Concessions and Vending Machine Areas</td>
<td>30</td>
</tr>
<tr>
<td>Stairs and Escalators</td>
<td>20</td>
</tr>
<tr>
<td>Washrooms</td>
<td>30</td>
</tr>
<tr>
<td>Kiss and Ride Areas</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Multi-Level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrances and Exits</td>
<td>50</td>
</tr>
<tr>
<td>Traffic Lanes</td>
<td>10</td>
</tr>
<tr>
<td>Parking Areas</td>
<td>1</td>
</tr>
<tr>
<td>Stairs and Escalators</td>
<td>20</td>
</tr>
</tbody>
</table>

### E. LANDSCAPING

Landscaping of transfer facilities is desirable for aesthetic as well as ecological reasons and should consist of plantings that will be compatible with the operation of the facility. The types of plantings and their placements should not interfere with (a) adequate lighting for the area thus resulting in a potential safety hazard to the patrons, (b) the proper placement of the traffic control devices, or (c) the ability of pedestrians, includ-
ing the handicapped, to use the facility. Care should be taken to use plants compatible with the climatic conditions of the area along with the ability to tolerate shade, wind, pollution, poor water conditions, salt, exhaust fumes and marginal soils. Also, they should be clean, reasonably decorative, long lasting, susceptible to few diseases, require little maintenance, and be readily available at a reasonable cost. Trees provide shade and visual interest, reduce glare, balance the city environment and are less costly to maintain when compared to shrubs and ground cover. Landscaping should be designed in such a manner that hiding places for vandals will be minimized.

Landscaping can provide an effective means for establishing pedestrian paths and walking patterns within the site. In parking zones, sufficient set back must be provided for all plants so the front or rear overhang of cars does not injure or kill them.

Extreme care should be exercised in placing shrubbery or other plants near the entrances and exits so that sight distances are not restricted. This requires that plants with limited growth patterns be considered so that the small plant of today will not develop into a major sight restriction in future years. Earth forms such as berms, mounds and swales are a good design tool to provide for low-cost screening, delineation, visual interest and drainage.

More specific information concerning plantings is available in "Transit Planting: A Manual". This document contains information assembled from rather extensive research on landscaping of bus stops, suburban terminals, and downtown stations. It lists the plants, shrubs and trees recommended for use in each of the ten hardiness zones in the United States and Canada. Plantings should be low maintenance, and the extent of landscaping should reflect the extent of maintenance capability.

F. SPECIAL DEVICES

In areas where security is a serious problem, consideration may be given to closed circuit television monitoring of larger lots or shelter facilities.

In some cases, it may be necessary to provide positive control of entering and exiting traffic. This is often accomplished by the use of some form of automatic or semi-automatic gate system. In some instances, entry or exit gates can be controlled by depositing money as a parking charge. However, since most park-and-ride facilities do not charge for parking, a more acceptable method is to provide gate activating tokens to transit riders, thus allowing them to raise the exit gate from the facility. When gates are used, care should be taken to locate them at points where queues of cars waiting to pass will not cause congestion.

G. MULTI-LEVEL PARKING STRUCTURES

Multi-level parking structures can be useful in highly urbanized areas as a terminal facility in the central business district fringe or major transfer mode facility. If high occupancy vehicle lanes leading into the CBD area are
II. MAINTENANCE

1. General

A clean and attractive site is essential to the retention or expansion of a successful park-and-ride operation. The type of site (new or existing), method of performing maintenance, and site location will generally determine the extent of maintenance required.

The daily commuter using the facility is impressed by the appearance of the site. As with restaurants, the use opinion spreads rapidly to other potential users of the facility. Therefore, a sound maintenance program adequately funded and staffed, should be planned well ahead of the date a park-and-ride facility is placed into operation.

2. Maintenance Responsibility

Determining the cost and the agency responsible for maintenance of a park-and-ride facility should be made early in the planning stages.

3. Maintenance Activities

The costs associated with maintenance activities are not well documented because of the limited experience of programs involving park-and-ride. Basically, these maintenance activities that should be considered are:

1. Periodic Inspection.
2. Pavement Repair.
3. Traffic Control Devices (signs and pavement markings).
4. Lighting.
5. Mowing.
7. Landscaping.
8. Shelters.
9. Snow and Ice Control.

Initial inspection of the site should be performed during the first few weeks following implementation of park-and-ride, in order to assess the frequency of maintenance activities that will require routine maintenance efforts on a periodic basis. A periodic inspection program should be scheduled as a routine maintenance activity.

The following items should be included on the initial inspection checklist:

1. Mowing.
2. Sweeping/Trash Pickup.
3. Inspection Frequency.


The pavement should not require any substantial maintenance work for several years following construction, assuming that the pavement strength was designed for transit vehicle loads and drainage is adequate.

Traffic control devices will probably not have a significant cost maintenance, as replacement will normally be governed by the periodic inspection of the site. Pavement markings should not require greater than annual replacement for centerlines in the normal traffic circulation patterns within the lot. Parking stall markings may have adequate life that will only require bi-annual replacement, depending on the local environment and conditions.

Unless there are security problems at the site that require a gate or guard, there will normally be no cost associated with this activity. Similarly, snow removal costs should be estimated, based on lot surface area estimates and the general frequency of snow experienced in the particular local geographic area.
PART III
DESIGN OF HIGH OCCUPANCY VEHICLE (HOV) FACILITIES

HOV facilities, whether they are exclusive roadways or reserved lanes, are usually incorporated into existing highway, rights-of-way where width and lateral clearances may be limited. Under these conditions it is often necessary to construct the HOV facility to a lower standard than would otherwise be used for new construction. While experience has shown that some reduction of design standards is possible without serious adverse effects on safety and performance, it has not been extensive enough to firmly establish new standards specifically for these types of facilities. The values presented in this section of the Guide should therefore not be regarded as absolute, but rather as the best guidance possible based on experience to date.

In applying the criteria that are presented, consideration should be given to the possible future use of HOV facilities. It is usually desirable to provide flexibility by designing for all vehicle types that may use a facility in the future. This can usually be done for very little if any additional cost.

Vertical clearance for underpasses should be the same as for any other roadway of the same functional class. This, for the most part, means a minimum clearance of 14 feet with 16.5 feet desirable. Where there is the possibility for future conversion to electric buses run from overhead wires, greater clearances should be provided as appropriate.

A. FREEWAYS

There are basically three types of HOV facilities applicable to freeways: completely separate facilities (separated from general use lanes by a barrier or an independent right-of-way), concurrent flow lanes, and contraflow lanes. There are no established warrants for their installation but an indication of their applicability can be derived from a summary of the advantages and disadvantages of each type. A completely separate facility is the safest, easiest to enforce and provides the most operational advantages for HOVs. Where consideration is being given to adding it to an existing freeway facility, it may require additional right-of-way or high cost structures. It has a high initial cost and therefore to be cost-effective the expected number of persons in HOVs should be generally higher than for the other types of HOV facilities.

Concurrent flow lanes (lanes adjacent to regular use lanes with no physical barrier between them) are generally less expensive initially than separate facilities. Initial installation costs can be low in the case where the existing roadway is used to incorporate the HOV lane by narrowing lanes and using a portion of the existing shoulder width. On the other hand, initial cost may be relatively high where the lane must be located outside the roadway, particularly in the case of adding the lanes to an existing facility where bridges must be rebuilt. Enforcement of the lane restriction